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18 JUL 03 E823627-1 D02481  
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## Request for grant of a patent

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K

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1. Your reference

P34671-/NBR/MEA

2. Patent application number

(The Patent Office will fill in this part)

0316863.0

18 JUL 2003

3. Full name, address and postcode of the or of each applicant (*underline all surnames*)

Hamilton Erskine Limited  
17 Moss Road, Ballygowan  
Newtownards, Co Down  
BT23 6JQ, Northern Ireland

Patents ADP number (*if you know it*)

967641300

If the applicant is a corporate body, give the country/state of its incorporation

United Kingdom

4. Title of the invention

"Improvements Relating to Glass"

5. Name of your agent (*if you have one*)

Murgitroyd &amp; Company

"Address for service" in the United Kingdom to which all correspondence should be sent (*including the postcode*)

Scotland House  
165-169 Scotland Street  
Glasgow  
G5 8PL

Patents ADP number (*if you know it*)

1198015

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and (*if you know it*) the or each application number

Country

Priority application number  
(*if you know it*)Date of filing  
(*day / month / year*)

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application

Date of filing  
(*day / month / year*)

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? (Answer 'Yes' if:

Yes

- a). *any applicant named in part 3 is not an inventor, or*
- b). *there is an inventor, who is not named as an applicant, or*
- c). *any named applicant is a corporate body.*

*See note (d).*

Patents Form 1/77

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Continuation sheets of this form

Description

15

Claim(s)

Abstract

Drawing(s)

6 + 6 (2)

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Priority documents

Translations of priority documents

Statement of inventorship and right to grant of a patent (Patents Form 7/77)

Request for preliminary examination and search (Patents Form 9/77)

Request for substantive examination (Patents Form 10/77)

Any other documents (please specify)

11.

I/We request the grant of a patent on the basis of this application.

Signature *Murgitroyd*  
Murgitroyd & Company

Date  
17 July 2003

12. Name and daytime telephone number of person to contact in the United Kingdom

Mark Earnshaw.

0141 307 8400

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1      Improvements Relating to Glass

2

3      The present invention relates to improved ballistic  
4      and blast- and hurricane-resistant optically  
5      transparent composite materials involving glass.

6

7      There have been many suggestions for "bullet-proof"  
8      and "blast-proof" transparent windows and the like,  
9      either for civilian purposes such as for use in  
10     aircraft, or for military purposes, especially  
11     protection against enemy and terrorist attack.  
12     However, with the developing threat from  
13     international terrorism and events such as those of  
14     September 11 2001, many governments and major  
15     organisations are re-appraising their security  
16     requirements. High velocity weapons and better  
17     explosives are increasingly available to terrorists  
18     and the like. Whilst traditional "bullet-proof"  
19     glass will still be required, there is now an  
20     increasing need for certain key installations,  
21     persons and equipment, especially in and around  
22     military and high governmental locations, to be

1     protected against a higher level of threat than  
2     previously considered necessary.

3  
4     Where pure optical transmission for a window is not  
5     a necessity, there are many available materials  
6     having high strength and impact resistance.  
7     However, where optical transparency of 'normal'  
8     windows and glazing is desired, e.g. for military  
9     base houses and offices, current forms of glazing  
10    are only adequate for protection against low  
11    velocity bullets (e.g. from small arms), and low  
12    levels of blast. Most current forms of 'bullet  
13    proof' glass use several layers of glass bonded by  
14    adhesive polymer film. The energy of the projectile  
15    is dissipated over increasingly large areas of  
16    blast. To some extent the projectile can be  
17    deformed or fragmented and can be deviated from the  
18    original line of attack. The energy is directed  
19    towards a direction different to the previous path,  
20    resulting in further dissipation of energy, e.g. as  
21    shown in figure 1.

22  
23    Typical design solutions involve either glass/glass  
24    combinations or glass/polycarbonate (PC)  
25    combination. The latter offer an advantage in that  
26    they are lighter than the former, but they often  
27    have delamination problems. The effect of bonding  
28    of PC to glass is also difficult as PC has a  
29    substantially higher rate of thermal expansion than  
30    glass. This causes high stress levels in the  
31    bonding interlayer during temperature changes which  
32    often leads to delamination.

1 The PC designs are often 'complex', particular as  
 2 the level of protection required increases. The  
 3 number of layers can cause problems with optical  
 4 interference and secondary image formation because  
 5 of the number of glass/PC interfaces. There may  
 6 also be weight or thickness limitations preventing  
 7 their use in particular applications. This is shown  
 8 in the following tables.

11 <b>Weapon type &amp;</b> 12 <b>Calibre</b>	13 <b>Class</b>	14 <b>Design</b>	15 <b>Thickness</b> (mm)	16 <b>Weight</b> (kg/m <sup>2</sup> )	17 <b>Trans- mittance</b> (%)
18 <b>Hand Gun</b> 19 <b>9mm Luger</b>	20 <b>BR2/C1</b>	21 <b>6<sup>2</sup>PC5<sup>2</sup>3-12-ESG6</b>	22 <b>35</b>	23 <b>47</b>	24 <b>77</b>
25 <b>Rifle</b> 26 <b>0.223</b> 27 <b>(5.56*45)hc</b>	28 <b>BR5/C3</b>	29 <b>8<sup>2</sup>6<sup>2</sup>PC6<sup>2</sup>6<sup>2</sup>PC6</b> 30 <b>8<sup>2</sup>PC8<sup>2</sup>6-12-</b> 31 <b>6<sup>2</sup>PC8<sup>2</sup>3-20-ESG6</b>	32 <b>39</b>	33 <b>71</b>	34 <b>64</b>
35 <b>Rifle</b> 36 <b>0.308</b> 37 <b>(7.62*51)</b>	38 <b>BR6/C4</b>	39 <b>8<sup>2</sup>8<sup>2</sup>6<sup>2</sup>PC6<sup>2</sup>6<sup>2</sup>PC6</b> 40 <b>8<sup>2</sup>PC8<sup>2</sup>3-12-</b> 41 <b>10<sup>2</sup>PC8<sup>2</sup>3-20-ESG6</b>	42 <b>49</b>	43 <b>93</b>	44 <b>?</b>
45 <b>Rifle</b> 46 <b>0.308</b> 47 <b>(7.62*51)hc</b>	48 <b>BR7/C5</b>	49 <b>6<sup>2</sup>8<sup>2</sup>8<sup>2</sup>PC8-20-</b> 50 <b>6<sup>2</sup>8<sup>2</sup>8<sup>2</sup>PC8</b>	51 <b>91</b>	52 <b>143</b>	53 <b>58</b>

29 US5665450 discusses the introduction of glass fibres  
 30 and glass ribbons into transparent composites, but,  
 31 as it states, the introduction of glass fibres into

1 an optically transparent polymer destroys the  
2 transparency of the polymer.

3  
4 US5665450 considers that the introduction of glass  
5 ribbons provide a higher degree of optical clarity  
6 and lower level of distortion than glass fibres.  
7 However the photographs in US5665450 indicating the  
8 degree of optical clarity of fibre and ribbon-  
9 reinforced materials still show distortion even  
10 based on photographic reproduction of relatively  
11 indistinctive photographs. Figure 7 shows  
12 percentage like transmission as a function of  
13 temperature and wavelength. However, it can be seen  
14 that the percentage transmission barely gets above  
15 80% at the lowest temperature and highest wavelength  
16 measured. The lowest temperature measured is at  
17 30°C, which is also not a temperature generally  
18 encountered in many countries on a regular basis. It  
19 is interesting that the percentage transmission in  
20 US5665450 was not measured at more temperate or  
21 freezing temperatures. Moreover, 80% optical  
22 transmission is very poor in comparison with the  
23 expectancy of 'normal' glass, which should be at  
24 least 90% at all temperatures. It is appreciated  
25 that the human eye can easily recognise or perceive  
26 a less than 100% optical transmission of light  
27 through a 'transparent' material.  
28

29 In essence, there is a requirement for an optically  
30 transparent composite material having about or at  
31 least 90% optical transmission over a range of  
32 temperatures, including below 0°C, and also able to

1 withstand high velocity ballistic projection whilst  
2 having a relatively low manufacturing cost.

3  
4 According to one aspect of the present invention,  
5 there is provided an optically transparent composite  
6 material comprising at least one glass/resin/glass  
7 lamination, wherein the resin is a PRR material  
8 having optical fibre-reinforcement therein.

9  
10 The term "PRR" refers to 'polycarbonate replacement  
11 resins', a range of materials provided by Chemetall  
12 GmbH of Frankfurt, Germany, and generally defined in  
13 their International Patent Application No WO  
14 01/38087A1. The PRR materials are a range of  
15 transparent cast resins that can consist of reactive  
16 acrylate and methacrylate monomers, acrylate and  
17 methacrylate oligomers, bonding agents and  
18 initiators. The content of WO 01/38087A1 defining  
19 these materials is incorporated herein by way of  
20 reference.

21  
22 The term "PRR" also extends to similarly provided  
23 polyurethane resins, often termed "PUR".

24  
25 A range of commonly available PRR materials are sold  
26 under the trade name Naftlolán®. The Naftlolán  
27 materials are provided in a range of different  
28 formulations to provide slightly different  
29 properties. A list of product data of certain  
30 polyurethane Naftlolán materials are listed in  
31 Tables 2 and 3 hereinafter, by way of example only.

1 PRR materials have been found to have several  
2 advantages over previously used polymer glass  
3 lamination layers. Firstly, the refractive index of  
4 PRR material overlaps very closely with many types  
5 of glass. Secondly, PRR materials have been found  
6 to expand and contract at very close rates with that  
7 of glass, thus leading to minimal if ever cracking  
8 or delamination (due to internal stress) during any  
9 thermal expansion and contraction of the composite  
10 material. Thirdly, PRR materials are relatively  
11 very easy to use and set in transparent composite  
12 materials, especially compared with processes of  
13 curing previously used types of polymers and resins.  
14 They are also useable in designs incorporating  
15 complex curves.

16

17 Because PRR materials have a co-efficient of  
18 expansion and contraction very close to glass, these  
19 materials are usable to provide optically  
20 transparent composite materials with glass over a  
21 much greater range of temperatures than, e.g. that  
22 shown in US5665450. In particular, the present  
23 invention is designed to provide a ballistic-  
24 resistant optically transparent composite material  
25 which is usable at temperatures even as low as -15°C  
26 to -40 °C, generally -20°C, e.g. the temperature of  
27 windows in military installations in certain  
28 countries such as Canada, as well as temperatures  
29 going up to 30°C to 40°C, such as the temperature of  
30 windows in more tropical countries. To that extent,  
31 the difference in co-efficiency of glass, such as a

1 normal silica-based glass, and PRR materials,  
2 deviates little over a wide temperature range.

3  
4 Table 4 hereinafter lists the refractive indices of  
5 a number of resins, including a number of the  
6 Naftolan range, indicating their close refractive  
7 index to that of glass in general.

8  
9 In general, the refractive index of the PRR  
10 materials are sufficiently close to readily  
11 available types of glass, such as a silica-based  
12 glass, that the optical transparency of the  
13 composite material of the present invention is as  
14 good as that from any current glass/glass or  
15 glass/PC laminations.

16  
17 The fibre reinforcement in the PRR layer of the  
18 composite material of the present invention can be  
19 provided by any known type of "fibre material", being  
20 for instance in the form of filaments, or in the  
21 form of particles such as beads, or even powders, as  
22 long as such fibre material wholly or very  
23 substantially has the same refractive index as glass  
24 across all or most the wavelengths of optical light.  
25 Such glass fibres are well known in the art, one  
26 such available product being sold under the trade  
27 name Tyglas by Fothergill Engineered Fabrics.

28  
29 The fibre reinforcement provide the PRR intermediate  
30 layer with improved strength because of their well  
31 known ability to laterally transmit impact energy.  
32 Meanwhile, PRR materials also have improved utility.

1 as a resin to band the fibre material fillers  
2 because of their similar co-efficient of thermal  
3 expansion and adhesive strength to glass.

4

5 In the present invention, the thickness of the glass  
6 and PRR layers, and the density of fibre  
7 reinforcement in the PRR layer, can vary according  
8 to the qualities of the final composite material  
9 desired. Cost and physical properties are factors  
10 in considering the thickness of the layers. One  
11 known ratio of thickness is glass/PRR/glass of  
12 6/20/4mm; this is provided by way of example only.

13

14 Indeed, a major facet of PRR material is that its  
15 strength is independent of its thickness. Many  
16 types of resins and adhesives only have strength for  
17 a minimal thickness, as their use is to bond  
18 together the layers (e.g. of glass) on each side,  
19 rather than provide any inherent strength of their  
20 own right. PRR has been found not only to provide  
21 good bonding to glass, but also have internal  
22 strength in its own right. The thickness of the PRR  
23 layer is therefore independent of the thickness of  
24 the glass layers either side.

25

26 The nature of "high velocity ballistic protection"  
27 can be defined in general terms as the difference  
28 between a hand gun and a rifle, e.g. above a NATO  
29 5.56 or 7.62mm ball.

30

31 According to a second aspect of the present  
32 invention, there is provided a process for making an

1        optically transparent composite material as herein  
2        before defined, comprising the steps admixing the  
3        PRR material with the optical fibre-reinforcement,  
4        and allowing the combination to cure and set between  
5        the two layers of glass.

6

7        Further information on the curing of PRR resins may  
8        be found in WO 01/38087A1.

9

10      Meanwhile, increasing power and sophistication of  
11      explosive-technology, means that 'blast-proof'  
12      optically transparent material is also desired  
13      having increasing strength. In this regard, it is  
14      now generally desired to provide blast-resistant  
15      optically transparent material having the ability to  
16      withstand a blast of 500kg TNT or equivalent at 40m.

17

18      US patent No 3953630 discloses a laminated  
19      transparent assembly suitable for use as a  
20      windscreen for a high speed vehicle wherein high  
21      strength flexible material is embedded in a plastic  
22      material, laid between two layers of glass. The  
23      flexible material extends beyond the transparent  
24      assembly, so as to be directly conjoined with the  
25      structure of the vehicle. Thus, as any blast causes  
26      deformation of the transparent assembly (as part of  
27      the impact absorption), the high strength flexible  
28      material provides a direct bond between the vehicle  
29      structure bolts and the transparent assembly,  
30      hopefully thereby resisting complete separation of  
31      the two and travel of the transparent assembly into  
32      the vehicle.

1  
2     However, US3953630 only discloses the use of  
3     polyvinylbutyral (PVB) as the plastic layered to  
4     provide the bonding between the glass sheets and the  
5     flexible material. In addition, manufacture of the  
6     transparent assembly in US3953630 requires an  
7     altering of the conventional laminating technique,  
8     in order to provide good bonding between a number of  
9     PVB sheets, and the glass. This requires pre-  
10    heating treatment, insertion of the full assembly  
11    including glass sheets in a closed bag to evacuate  
12    all air, followed by heating in a autoclave with  
13    high pressure. This method of manufacture has not  
14    lent itself to cost-efficient production for a  
15    number of transparent assemblies, other than for the  
16    very special uses such as our aircraft windscreens  
17    as mentioned.

18  
19    Moreover, PVB in particular is a material only  
20    designed to provide good bonding between glass  
21    layers. It is typically only 1-2mm thick. Further  
22    thickness of layer is not desired, as PVB has little  
23    internal strength in its own right.

24  
25    In a third aspect of the present invention, there is  
26    provided a laminated optically transparent assembly  
27    comprising at least one glass/resin/glass  
28    lamination, and having one or more high tensile  
29    strength flexible material reinforcement pieces  
30    extending laterally from the resin layer to provide  
31    increased attachment of the assembly to a surround,  
32    wherein the resin is a PRR material.

1  
2 PRR materials are those as defined herein above. As  
3 well as the greater similarity of refractive index  
4 and co-efficient of thermal expansion of PRR  
5 material to glass, the PRR-flexible material and  
6 PRR-glass bonding has been found to be superior to  
7 that of prior materials such as PVB.

8  
9 Meanwhile, the assembly of the present invention  
10 still provides the degree of flexibility desired for  
11 a blast-resistant window, with the reinforced  
12 attachment of the window to the surround, such as  
13 the window rebate of frame.

14  
15 The high tensile strength flexible material may be  
16 similar to that disclosed in US3953630, i.e. woven  
17 fabric or woven glass fibre material or polyester  
18 fibre material. One such product is Kevlar®.

19  
20 Preferably, the flexible material extends wholly or  
21 substantially around opposites sides of the complete  
22 transparent assembly, to provide flexibility of  
23 attachment to the surround.

24  
25 As for the ballistic-resistant material described  
26 hereinabove, the thickness of the glass and resin  
27 layers of the blast-resistant assembly can follow  
28 those well known in the art. One suitable dimension  
29 for the glass/resin/glass is 4mm glass, 4mm PRR and  
30 3mm glass.

31

1 The thickness of the PRR layer can indeed be up to  
2 40-50mm thick, as PRR has inherent strength  
3 independent of thickness as mentioned above. To  
4 that extent, the PRR material can be as thick and  
5 therefore as strong as desired, as all the strength  
6 from a blast is taken by the resin (whilst any glass  
7 shatters).

8

9 The ability to provide a PRR layer of any thickness  
10 provides a further benefit.

11

12 Thus, according to a forth aspect of the present  
13 invention, there is provided a blast-resistant  
14 composite material comprising at least one layer of  
15 PRR material having at least one reinforcement piece  
16 extending wholly or substantially across the PRR  
17 layer.

18

19 Preferably, the reinforcement piece is a series of  
20 strips of bars or other reinforcement means, more  
21 preferably forming a grid or grid-like structure  
22 wholly or substantially across the composite  
23 material.

24

25 The PRR material is that as defined hereinabove.  
26 The reinforcement piece can be one or more of woven  
27 rovin, webbing, webbing material or even metal  
28 material. The use of a metallic grid provides the  
29 same effect as a "muntin" system which uses metallic  
30 reinforcement grid alongside a glazing panel, but  
31 not actually therein. The present invention  
32 therefore achieves the same effect and strength as a

1 muntin system, but as a one piece assembly, thereby  
2 significantly reducing assembly and installation.

3

4 The blast-resistance is achieved because the PRR  
5 layer can be any thickness desired, e.g. up to 40-  
6 50mm, which is able to accommodate reinforcement  
7 pieces, whereas previous resins were not able to  
8 achieve such thickness, and thereby accommodate  
9 reinforcement therein.

10

11 The benefit of achieving reinforcement within the  
12 PRR material is that each 'section' created by the  
13 reinforcement piece or pieces, e.g. each small  
14 section within the grid, can be regarded as having  
15 its own frame, as thus regarded as a separate  
16 section in terms of analysis against blast. As is  
17 well known in the art, the blast-resistance of a  
18 small section is greater than that of a large  
19 section. By dividing the composite panel into a  
20 number of small sections, significant blast-  
21 resistance is achieved.

22

23 It is noted that the optical transparency of blast-  
24 resistant panels using the muntin system is not as  
25 important as that described for other aspects of the  
26 present invention, so that the comparative  
27 refractive index is not as important as that as  
28 described above in relation to other aspects of the  
29 present invention.

30

31 It will be recognised by those skilled in the art  
32 the composite materials and assemblies could also be

1 used to provide hurricane or the like resistance,  
2 and thus the present invention is extended thereto.

3 Embodiments of the present invention will now be  
4 described by way of example only and with reference  
5 to the accompanying drawings in which:

6

7 Figure 1 is schematic cross-sectional view of the  
8 impact of a projectile against a current multi-glass  
9 laminated window pane;

10

11 Figure 2 is a cross-sectional view of a optically  
12 transparent composite material according to one  
13 embodiment of the present invention;

14

15 Figure 3 is a laminated optically transparent  
16 assembly according to a second embodiment of the  
17 present invention.

18

19 As previously mentioned, figure 1 shows how the  
20 energy of a projectile is dissipated over  
21 increasingly large areas of glass of a known glass  
22 PC lamination pane, leading to a large area of glass  
23 shattered from the left hand side.

24

25 Figure 2 shows a optically transparent composite  
26 material 2 comprising a glass/resin/glass  
27 lamination. Within the PRR resin layer 4 are a  
28 series of traditional fibre glass woven rovings 6.

29

30 To produce the material, the rovings 6 were secured  
31 between two panes of glass 8, and the PRR resin 4  
32 was injected into the cavity. The resin 4 flows up

1 the inside of the glass 8 and disperses through the  
2 woven roving 6, wetting the fibres and forming an  
3 excellent bond.

4

5 Figure 3 shows a blast-resistant assembly 10 mounted  
6 to a wall 12. Between the two panes of glass 14, a  
7 2 inch wide unidirectional glass fibre woven roving  
8 16 was bonded into the same PRR resin 18 as  
9 mentioned above. The complete assembly 10 was  
10 located in the rebate of a window frame 20, and the  
11 roving reinforcement material 16 fixed to the frame  
12 20 by adhesive, and also by means of a lateral bolt  
13 22.

14

15 The assembly 10 was tested in a Hannsfield 20k-w  
16 tensometer. Loads in access of 8000N were applied  
17 before the fibre woven 16 broke. Considerably  
18 greater loads could be achieved with the use of  
19 thicker fibres or different types of fibres.

20

21 The present invention provides ballistic-resistant  
22 and blast-resistant assemblies providing protection  
23 against much higher levels of protection from high  
24 velocity weapons and explosives than currently known  
25 with current forms of glazing. Production of the  
26 assemblies is also comparatively simple and cost  
27 effective compared to previous types of similar  
28 assemblies, which used less suitable polymers and  
29 plastic material.

1/8

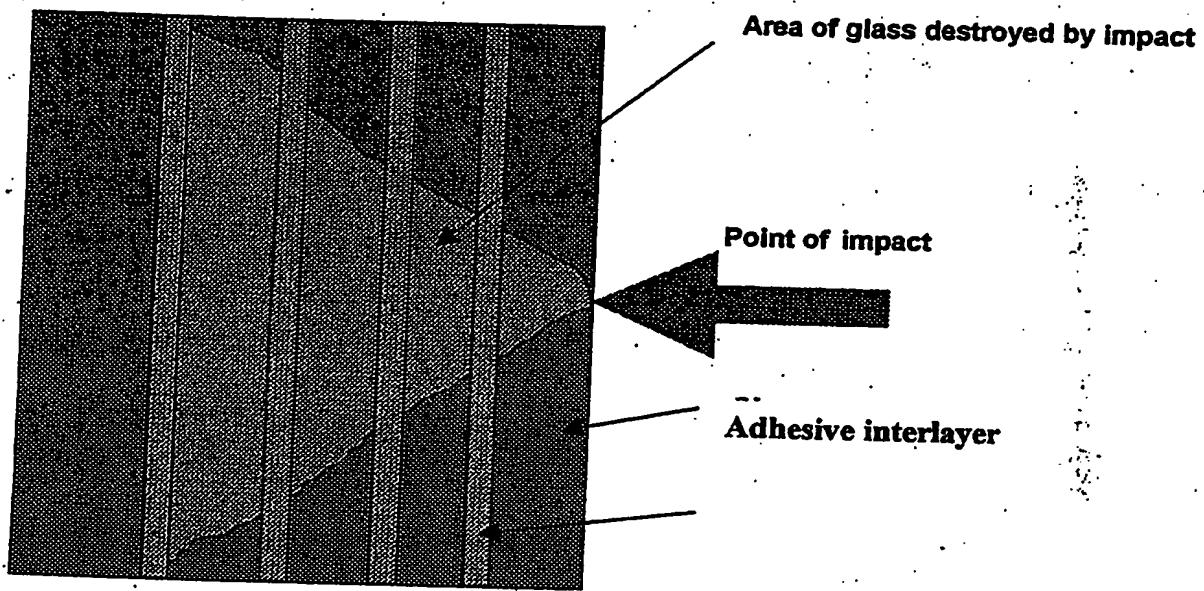
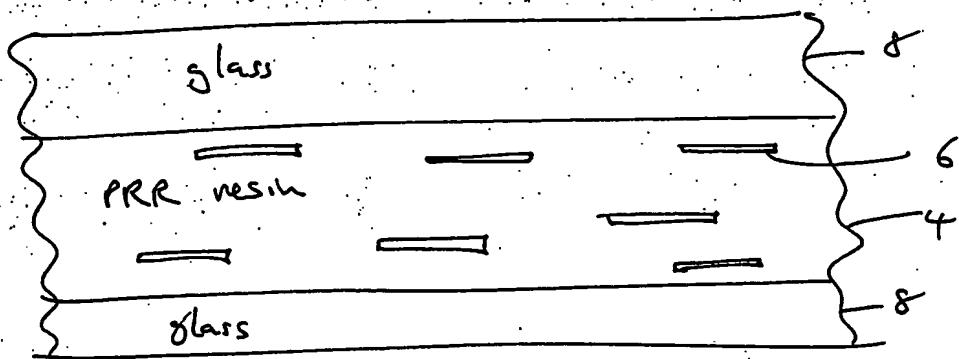


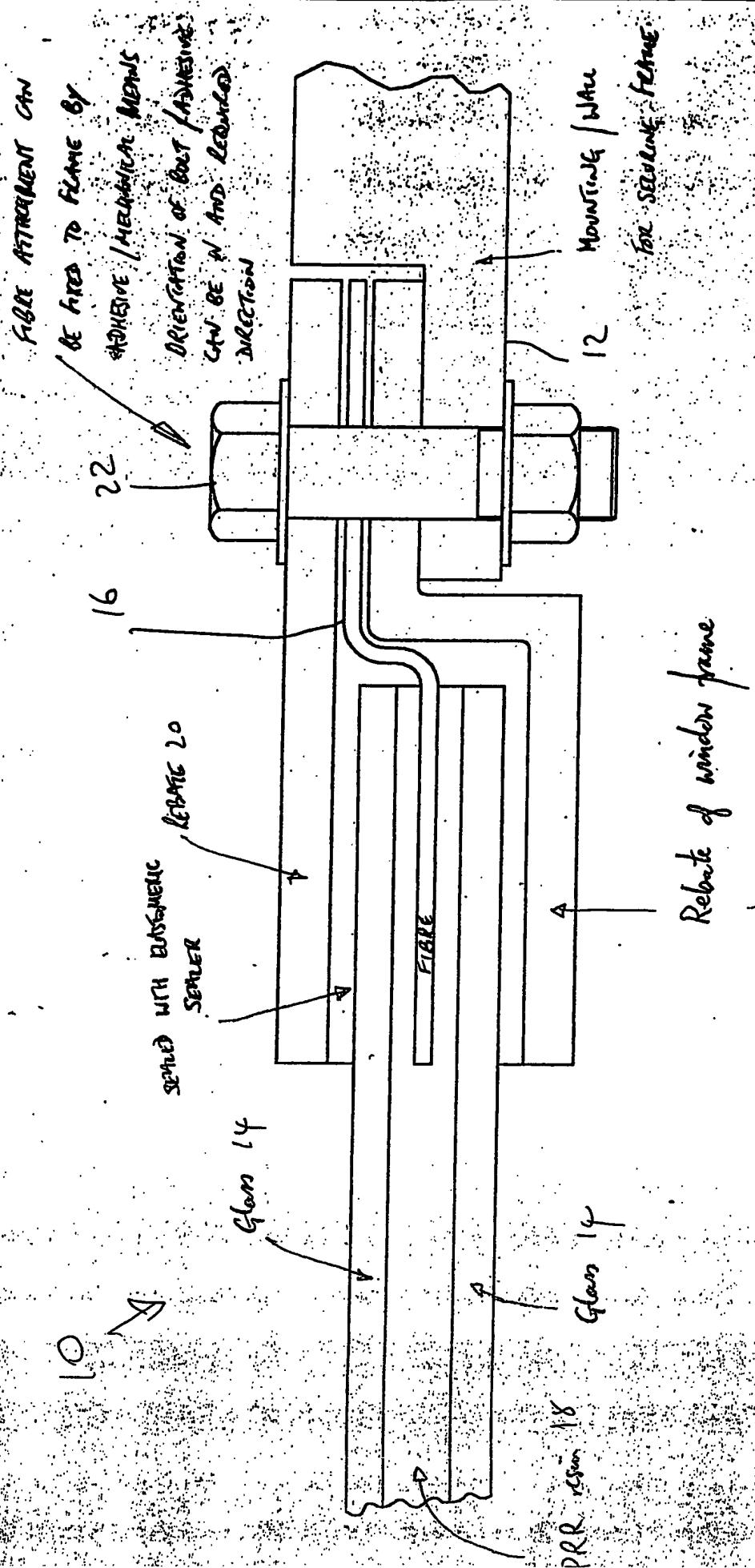
Fig 1

2/6

Fig 2

2 ✓





## Product Data of Polyurethane Composite Materials

Physical Properties		Naftolan PU-A 700 / PU-B 304	Naftolan PU-A 206 / PU-B 606	Naftolan VP-PA 0911 / VP-PB 2110	Naftolan VP-PA 1011 / VP-PB 2110	Naftolan VP-PA 2601 / VP-PB 2110	Naftolan VP-PA 0511 / VP-PB 2810	Naftolan VP-PA	Naftolan VP-PA	Standard
Density										
Max	Min									
Range possible in one layer										
Strength & Stiffness										
Tensile strength [MPa]	16	16	18	18	18	18	5	5	2.1	DIN 53 504
25% module [MPa]	5	1.2	15	6	12	12	0.7	0.7	0.7	DIN 53 504
50% module [MPa]	6	1.7	14	7	1.8	1.8	1.2	1.2	1.2	DIN 53 504
100% module [MPa]	8	2.5	15.5	10	3.2	3.2	1.8	1.8	1.8	DIN 53 504
Tensile modulus										
Tensile yield point	180	360	150	160	150	150	120	120	120	DIN 53 504
Elongation at break [%]										
Compressive strength										
Compressive modulus										
Compressive yield point										
Flexural strength										
Flexural modulus (also called modulus of elasticity)										
Flexural yield point										
In-plane shear strength										
In-plane shear modulus										
Toughness										
Variation with loading rate										
Hardness										
Shore A hardness	90	73	85	90	65	65	55	55	55	DIN 53 505
Adhesion to glass										
Bond shear strength										
Compression shear strength [MPa] 4/24 mm glass/glass	18	7.5	20	20	10	10	2.5	2.5	2.5	
Thermal										
Thermal coefficient of expansion										
Thermal conductivity										
Specific heat capacity (at 20°C)										
Resistance										
Resistivity										
Temperature coefficient of resistance										

These values are for guidance only and do not represent a specification.

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# Product Data of Polyurethan Composite Materials

Physical Properties	Naftolan PU-A 700 / PU-B 304	Naftolan PU-A 208 / PU-B 606	Naftolan VP-PA 0911 / VP-PB 2110	Naftolan VP-PA 1011 / VP-PB 2110	Naftolan VP-PA 2601 / VP-PB 2110	Naftolan VP-PA 0911 / VP-PB 2910	Standard
Flammability							
Melting point							
Boiling point							
Smoke emission							
Critical Oxygen Index (COI) (minimum oxygen fraction in an oxygen:nitrogen mixture which will support steady state combustion of the plastic. Plastics with COI >0.21 are self extinguishing)							
Chemical Resistance							
Acids							
Alkalies							
Organic solvents							
Weatherability/degredation							
Ageing - temp cycling test							
UV absorption							
Adsorption of water							
Additional Data							
Viscosity (23°C) [mPas]	Component A	450	320	600	515	435	380
Viscosity (23°C) [mPas]	Component B	3250	85	85	85	85	85
Viscosity (23°C) [mPas]	Mixture	2550	200	225	200	245	230
Specific weight (23°C) [g/cm³]	Component A liqu	1.02	1.01	1.03	1.02	1.02	1.01
Specific weight (23°C) [g/cm³]	Component B liqu	1.04	1.05	1.05	1.05	1.05	1.05
Specific weight (23°C) [g/cm³]	Mixture liqu	1.04	1.037	1.04	1.03	1.03	1.02
Volume Shrinking [%]		2	2	4	4	3	2
Processing time (23°C) [min]		45	15	40	30	30	30
Cutting time (23°C) [h]		12	48	12	24	24	12
Storage time before delivery (18°C to 23 °C) [d]		4	6			4	
Shore A hardness after 1 day (cured resin) DIN		65		75	65	50	40
Shore A hardness after 7 days (cured resin)		90	73	95	80	65	55
Thermal conductivity (DIN 52612) [W/(m²K)]		0.18					DIN 52612
Transmittance (DIN 67537) (assembly 6/84/mm) [%]		90					DIN 67 507
Transmittance (DIN 67507) (assembly 6/154/mm) [%]		88					DIN 67 507
Transmittance (DIN 67507) (assembly 6/204/mm) [%]		88					DIN 67 507

These values are for guidance only and do not represent a specification.

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Table 4

Refractive Index  
liquid / cured Resins (at 20°C)

Resin	$n_{D20}$ liquid	$n_{D20}$ cured
UV 11	1,4362	-
UV 22	1,4417	1,4813
UV 33	1,4396	-
ICE-Gießharz EP 1309-103	1,4434	-
UV 203	1,4370	-
S 700 M	1,4299	1,4713
S 696 M	1,4272	-
Naftolan VP-PA 0511	1,4542	-
Naftolan VP-PA 1011	1,4568	-
Naftolan PU-A 206	1,4540	1,4844 *
Naftolan VP-PB 2110	1,4169	-
Naftolan PU-B 606	1,4777	-
Naftolan VP-PA 2601	1,4553	-
Naftolan PU-A 700	-	-
Naftolan PU-B 304	1,4739	-

\* cured with corresponding B component

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